19th SANCHIAS SYMPOSIUM

"hydro-illogical cycle"

Skukuza - 18-20 September 2018

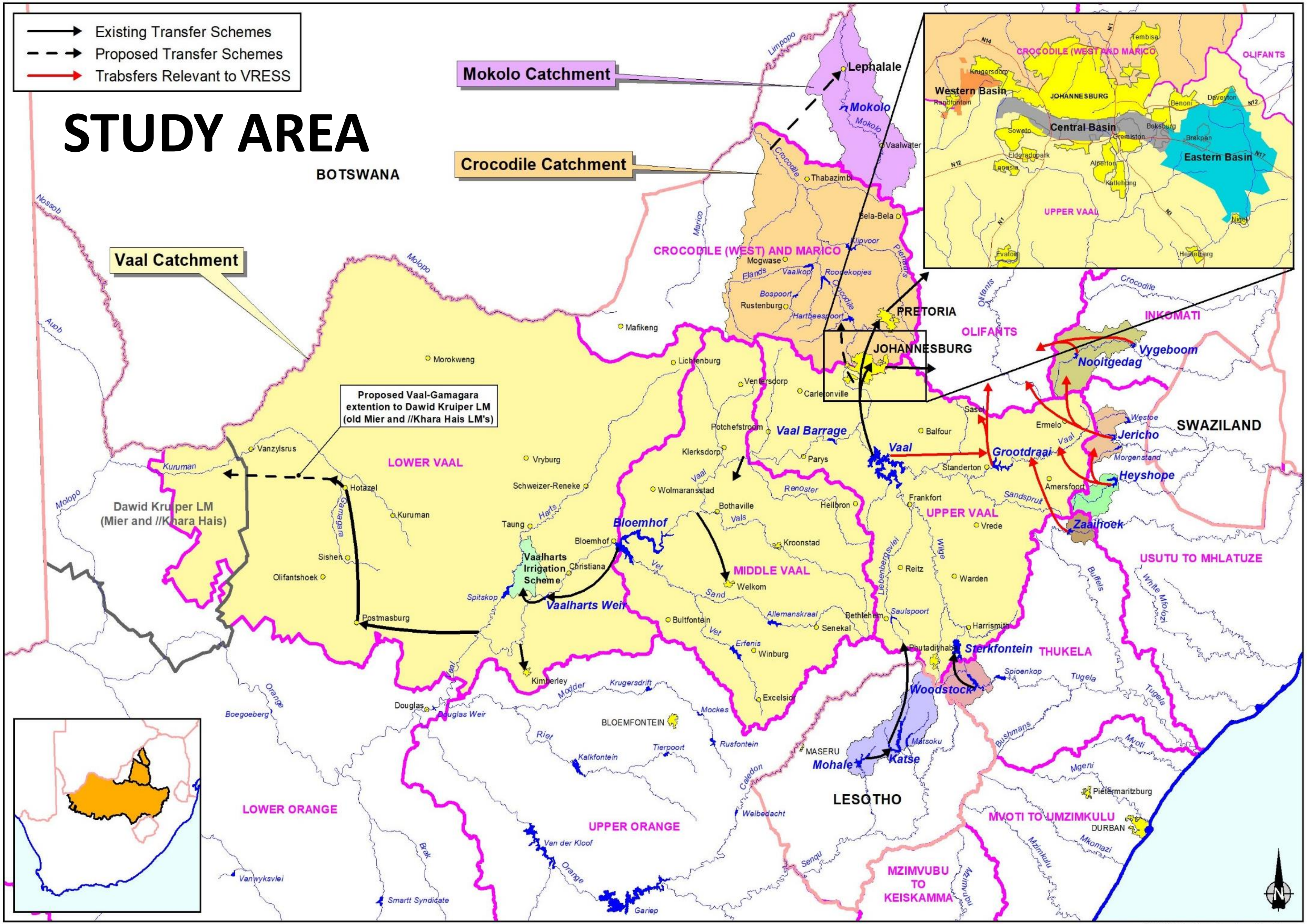
Lessons learned from three decades of water resource planning of the Integrated Vaal River System

**P. G. van Rooyen, R. S. McKenzie,
J.I. Rademeyer**

Layout

- Integrated Vaal River System
- Planning journey – since 1983
  - Planning activities
  - Infrastructure development
  - Legislation and institutional changes
  - Drought Risk Analysis
- Decision Support Systems
- System Status 2018
- Conclusions
- Recommendations

STUDY AREA



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Planning History

1983	Drought Analysis (before systems & stochastic models)
1990	**Vaal River System Analysis**
Since 1989	Vaal River Annual Operating Analysis
1996	**Vaal Augmentation Planning Study (VAPS)**
2001	Vaal River System Analysis Update Study (VRSAU)
2001	Thukela Water Project Feasibility Study
2003	**Thukela Water Project Decision Support Phase**
2004	Internal Strategic Perspectives (ISP)
2004	**Vaal River Eastern Subsystem Augmentation Project (VRESAP)**
2007	**Potential Savings Through WC/WDM in the Upper and Middle Vaal WMA**
2009	**Vaal River System: Large Bulk Water Supply Reconciliation Strategy**
2009	**Development of an Integrated Water Quality Management Plan for the Vaal River System**
2010	**Comprehensive Reserve Determination: Integrated Vaal River System**
2010	Comparative Study Between LHWP Phase II And Thukela Water Project
2012	**Classification of Significant Water Resources (WMA 8,9,10)**
2013	**Feasibility Study for the Long-Term Solution to address the AMD from the Eastern, Central & Western mining basins**
2015	Continuation of the IVRS Reconciliation Strategy Study (Phase 1)
2016	Classes and Resource Quality Objectives of Water Resources for Catchments of the Upper, Middle and Lower Vaal
Current	Vioolsdrift Feasibility Study (yield replacement), Continuation of Reconciliation Strategy

Drought early 1980's

- Drought planning using HEC model.
- Constructed weir scheme, Vaal Dam to Grootdraai Dam:
  - Never used due to floods – all dams filled.
- Planned the Orange – Vaal Weir Scheme:
  - Found to the "feasible".
- Lesotho Highlands Water Project – Treaty 1987.
- Vaal River System Analysis Study, completed 1990: >
- Annual Operating Analysis, first in 1989.

Lesson: *Money for planning and development increases when rain subsided, rivers don't flow and dams are low.*

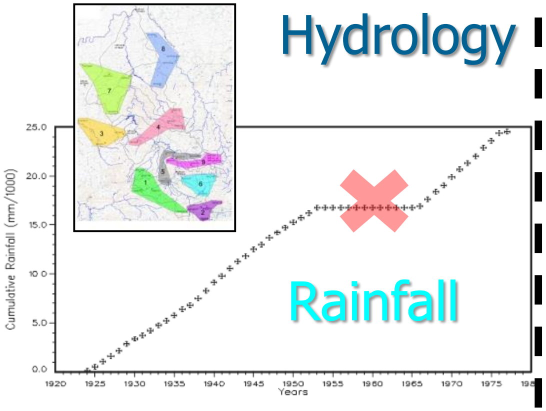
Vaal River System Analysis - 1990

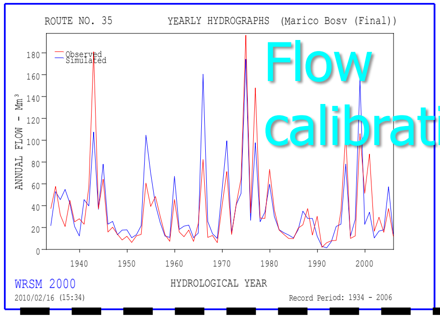
- Derived rigorous multi catchment hydrology.
- Developed and calibrated the water quality salinity model.
- Configured the integrated systems model with water quality (salinity) for the first time.
- Compiled “**Analysis Procedures Manuel**”.
- Developed “Multi-catchment stochastic” (**McKenzie & Pegram, 1991**) flow generation model enabling **sophisticated risk analysis**.
- First model revision (Mark 2, 1993).

Lesson : *New methods, techniques and software need to be prototyped, pilot tested, pier reviewed and should be accompanied by appropriate training material before it is rolled out to other areas.*

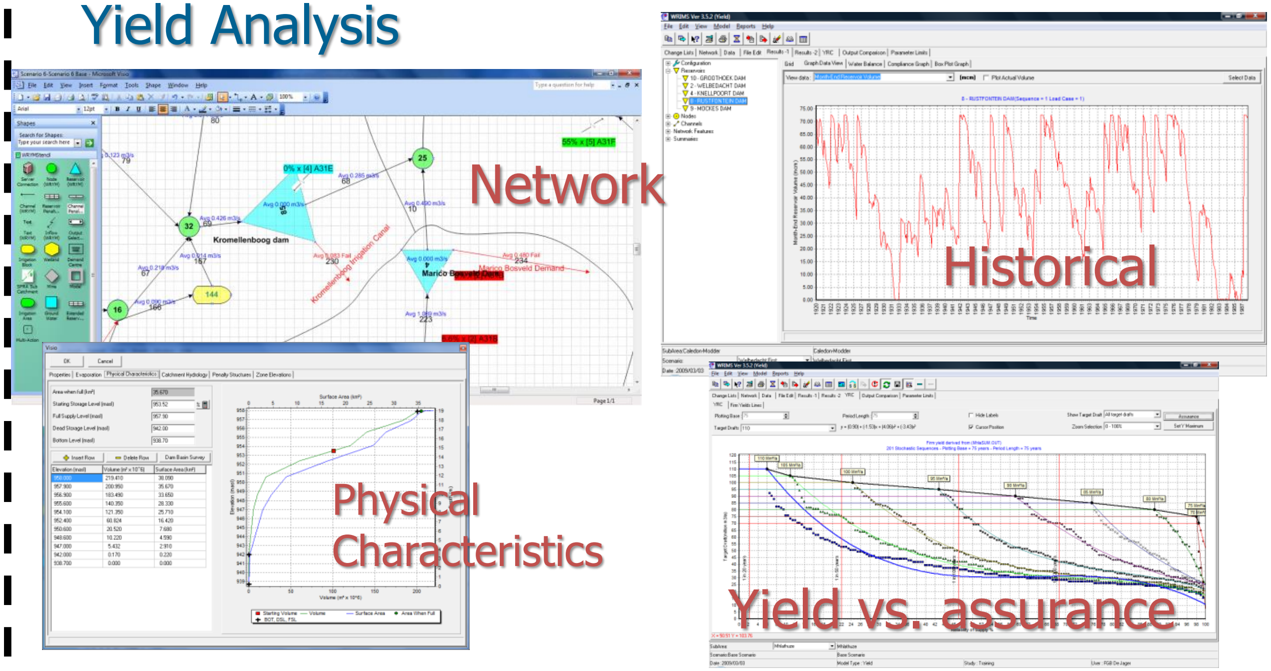
Hydrological & Systems Analysis

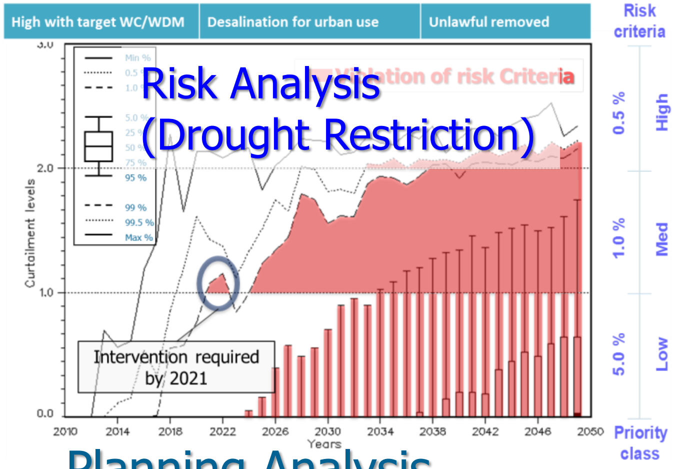
Hydrology





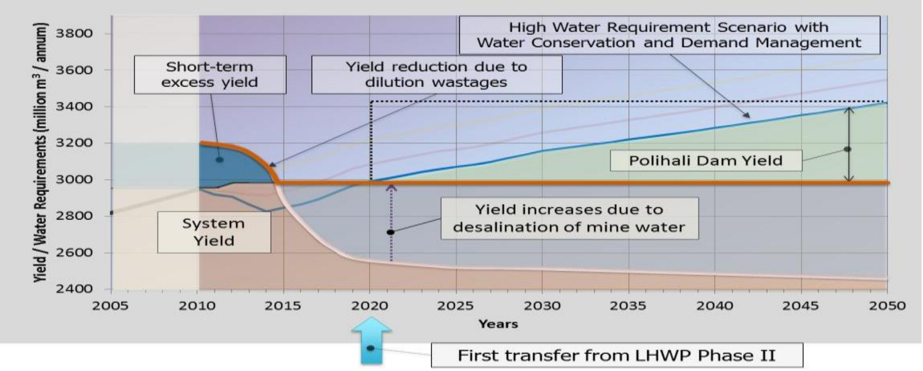
Yield Analysis





Planning Analysis

Reconciliation Scenario Water Balance



Water User Risk Criteria

User Sectors	User priority classification (Criteria: risk of curtailments)		
	Low (5 %)	Medium (1 %)	High (0.5 %)
	Proportion of water demand (%)		
Domestic	30	20	50
Industrial	10	30	60
Strategic industries	0	0	100
Irrigation	50	30	20

Restriction levels: 0 1 2 3

Gardening Water

Human Consumption Hygiene

Power Generation Petro Chemical Industry

Annual Crops

Permanent Crops

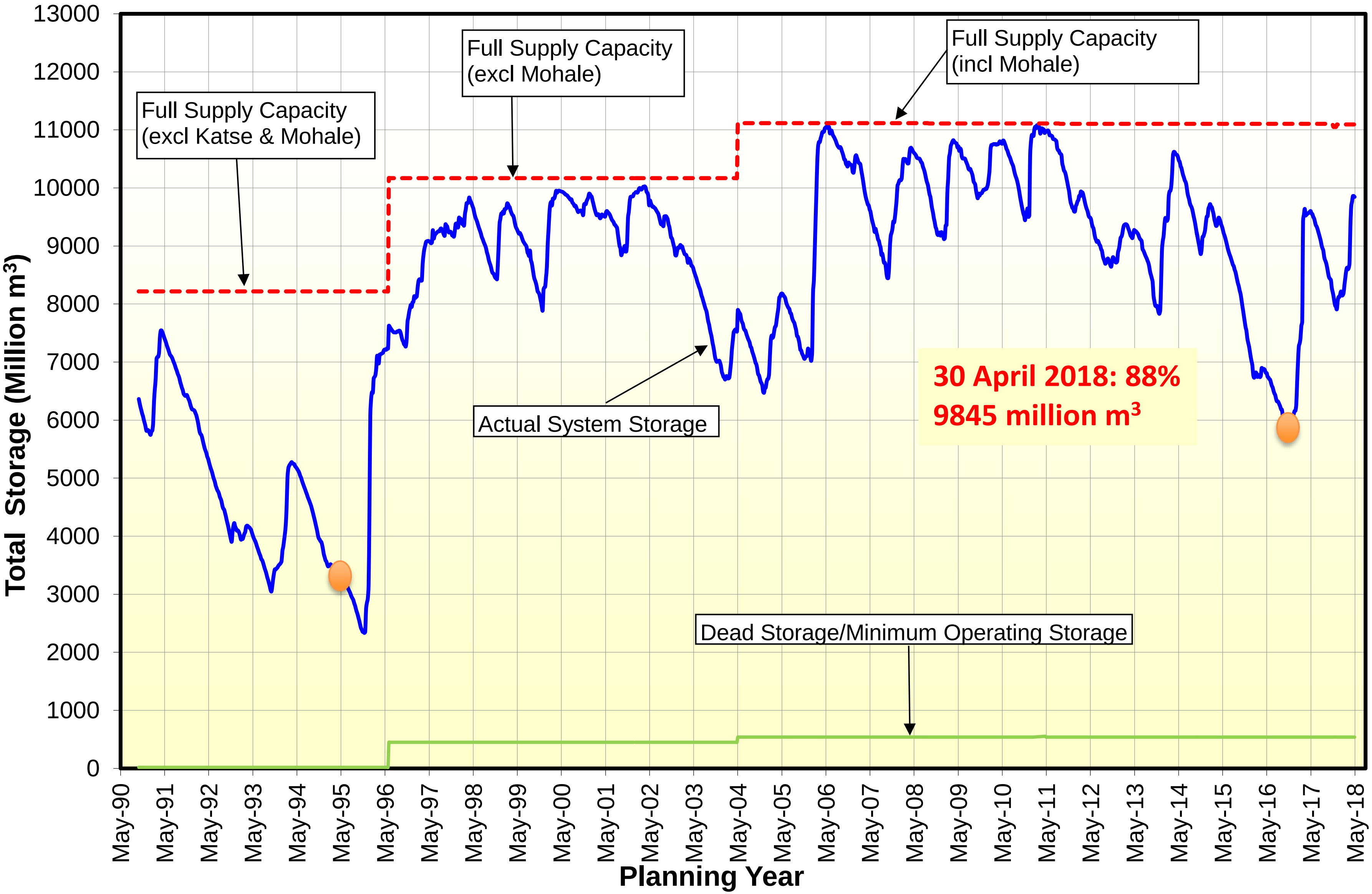
All Low Priority Use Restricted

All Low & Medium Restricted

All Use Restricted

Total System Storage Trajectory - since 1990

Figure 1:Total Vaal River system storage (from May 1990 to April 2018)



30 April 2018: 88%
9845 million m^3

Vaal Augmentation Planning Study, 1996

- Evaluated, compared and shortlisted water resource infrastructure options to augment the Vaal River System.
  - Further transfer from Thukela River System.
  - Transfer from Orange River.
  - Lesotho Highlands Water Project – further phases.
  - Mzimvubu River System – reconnaissance study.
- Outcome was that a further phase of the LHWP and the Thukela Water Projects are comparable and should be investigated further.
- Commissioned the Thukela Water Project Feasibility Study.

National Water Act 1998

- Introduced current water rights structural.
- Methods to assess Ecological Water Requirements was incorporated in main stream planning.
- Stakeholder participation became a core activity:
- Preamble:

*Recognising the need for the **integrated management** of all aspects of water resources and, where appropriate, the **delegation of management functions** to a regional or catchment level so as to **enable everyone to participate**’*

1998: Uses of models

- Risk based analysis for:
  - Development planning
  - System operating analysis
- Assessment of Ecological Water Requirements.

Lesson:

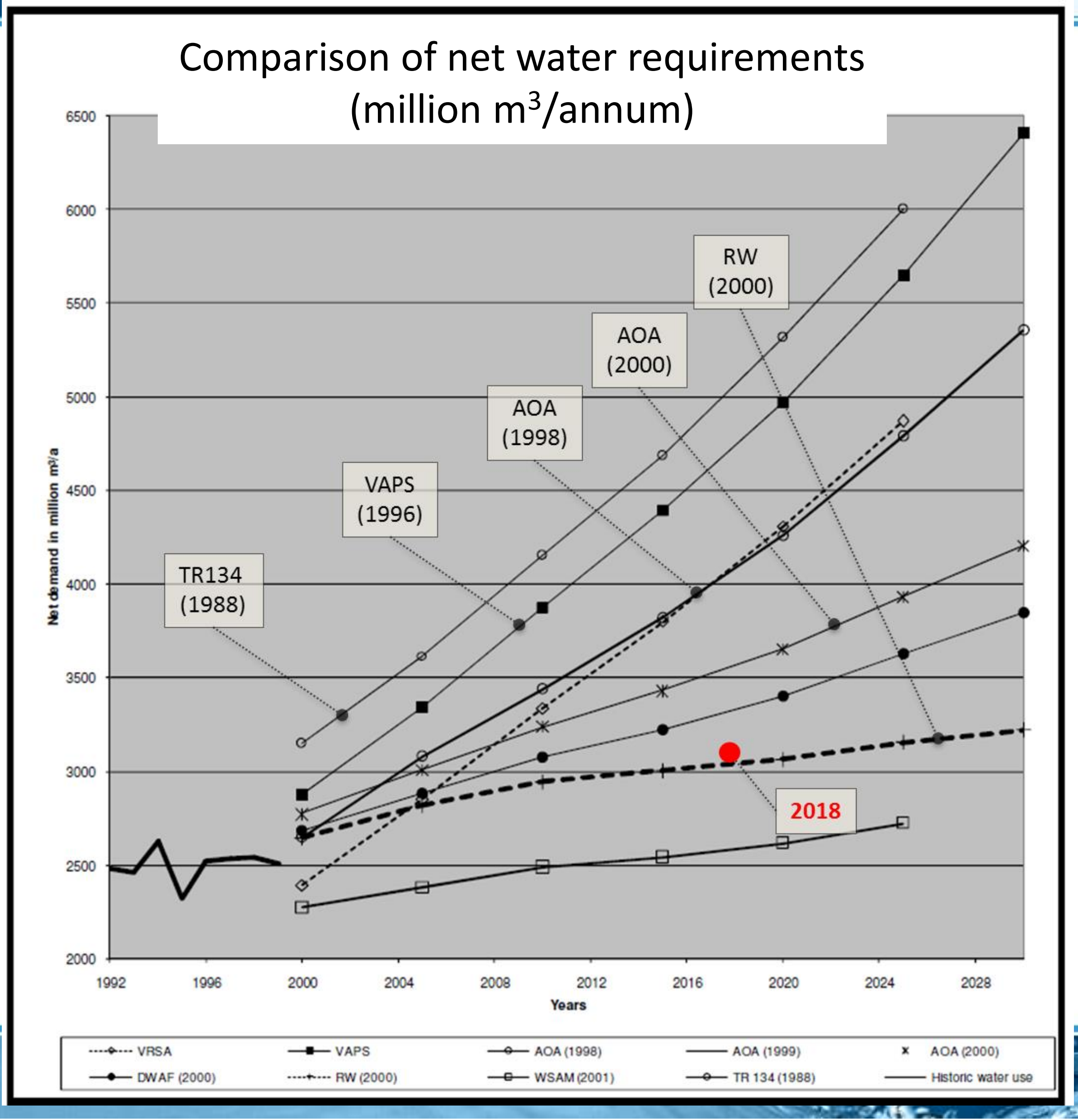
***Consistent** application of:*

- *Rigorous hydrological information.*
- *Analysis techniques and models.*

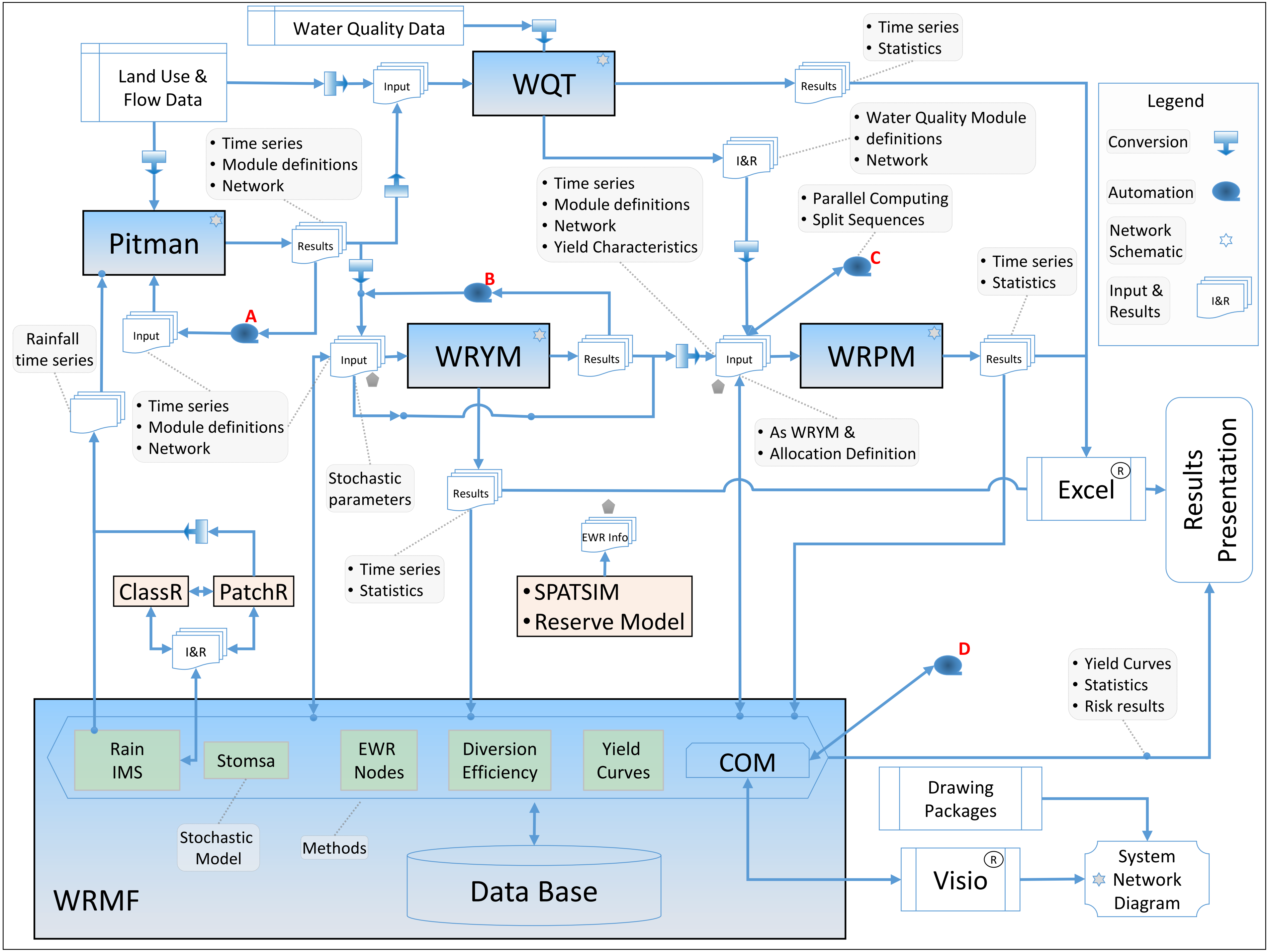
Focused debates on the implications of the results as opposed to the input information or accuracy.

Models provided the means to evaluate relative efficiency by assessing alternatives also referred to as scenario planning.

2007: Water Requirement Scenarios



Comparison of net water requirements
(million m^3/annum)


Water Quality Data
Land Use &
Flow Data
Input
WQT
Results
Time series
Statistics
Time series
Module definitions
Network
Water Quality Module
definitions
Network
I&R
Time series
Module definitions
Network
Yield Characteristics
Parallel Computing
Split Sequences
Legend
Conversion
Automation
Network
Schematic
Input &
Results
I&R
Pitman
Results
C
B
A
Time series
Statistics
Rainfall
time series
Input
Input
WRYM
Results
Input
WRPM
Results
Time series
Module definitions
Network
As WRYM &
Allocation Definition
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parameters
Results
Excel
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Results
Presentation
EWR Info
Time series
Statistics
ClassR
PatchR
SPATSIM
Reserve Model
I&R
D
Yield Curves
Statistics
Risk results
Rain
IMS
Stomsa
EWR
Nodes
Diversion
Efficiency
Yield
Curves
COM
Drawing
Packages
Stochastic
Model
Methods
Data Base
Visio
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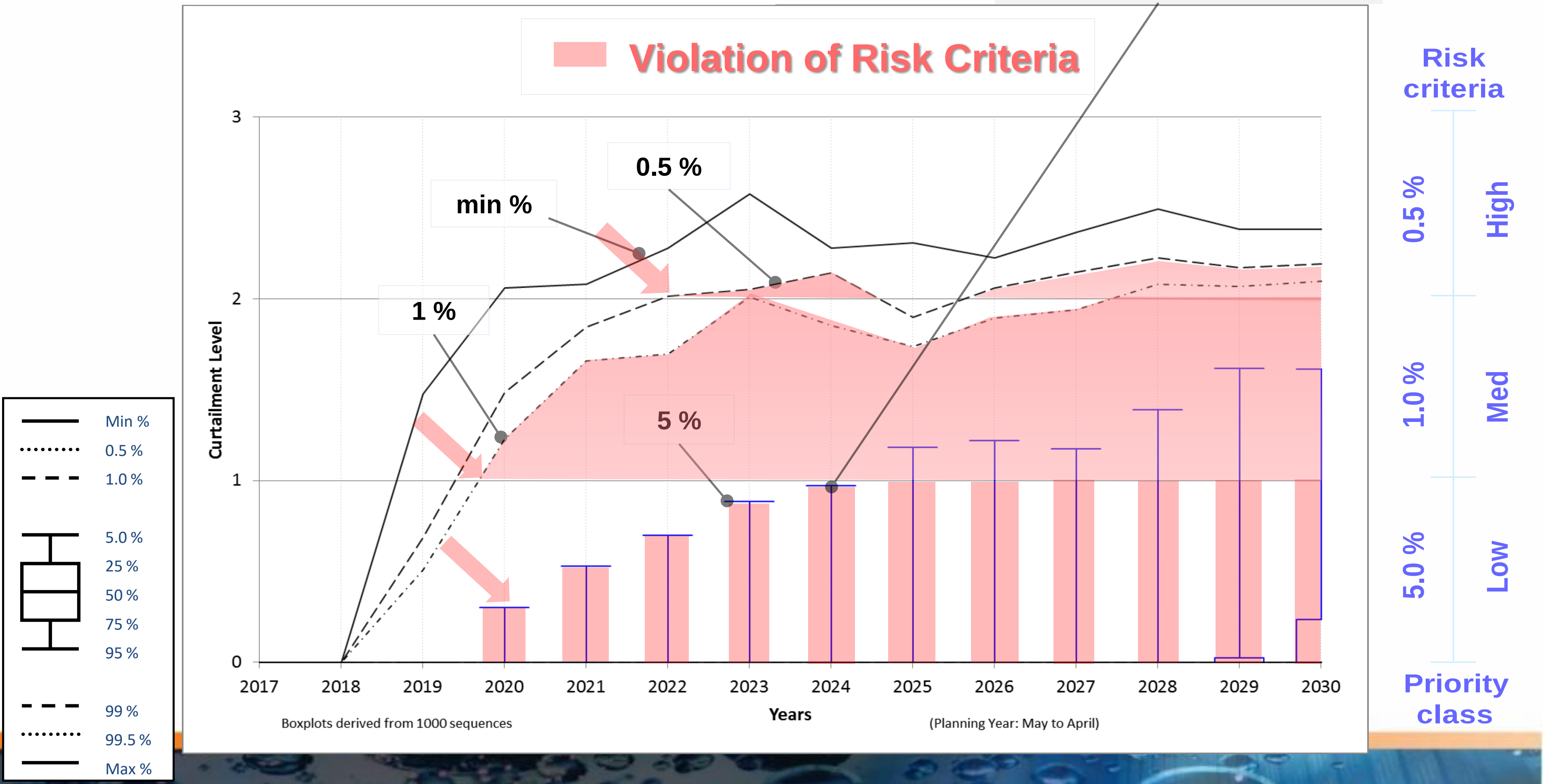
System
Network
Diagram
WRMF

Risk of Drought Restrictions Status

- **High Demand Scenario**
- **Desalination Jan-2022**
- **LHWP II not implemented**

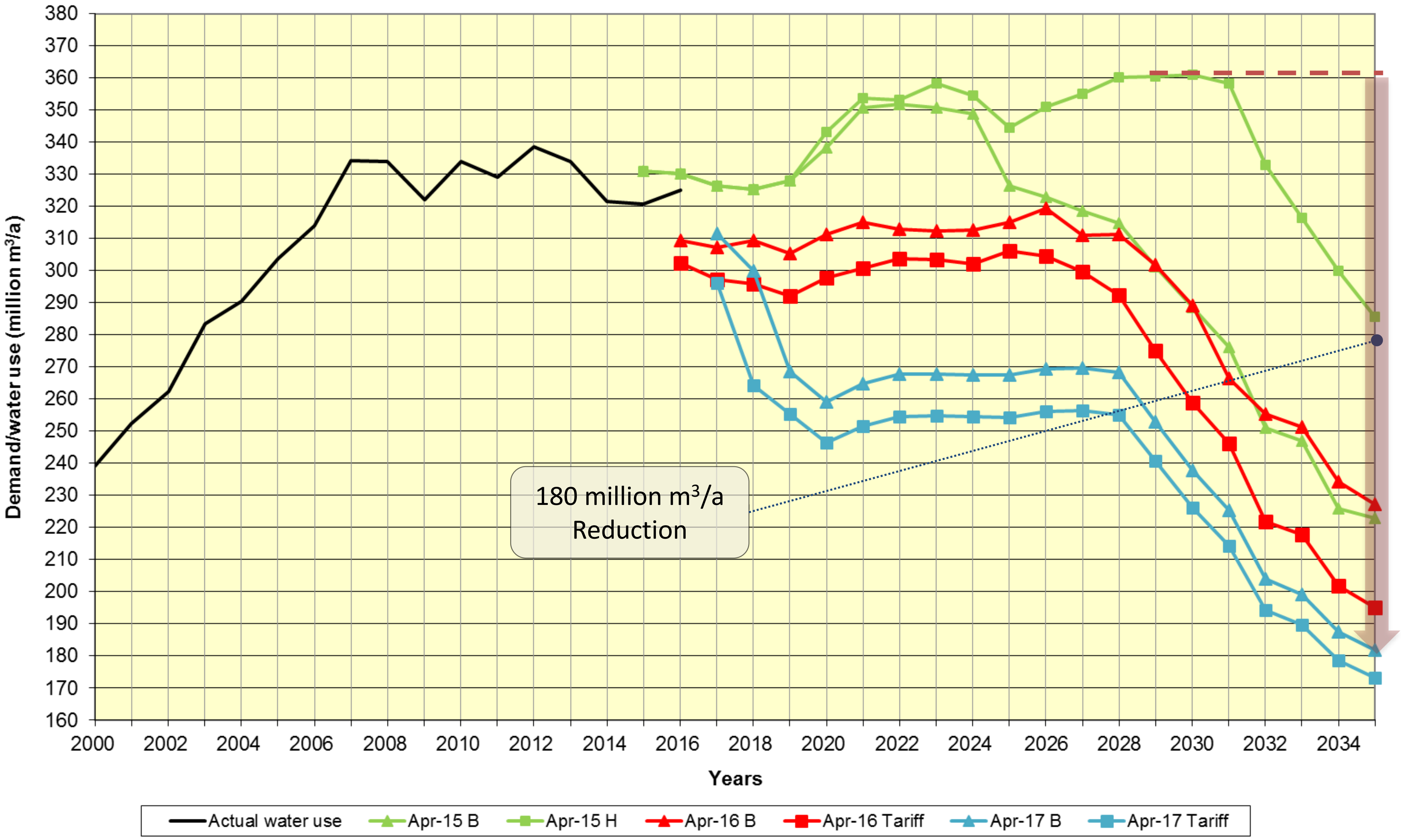
By 2024 Level 1 Curtailment occurs at 5% risk:

- 50% Irrigation Curtailment
- 30% Urban Curtailment



Eskom (Total for Integrated Vaal River System)

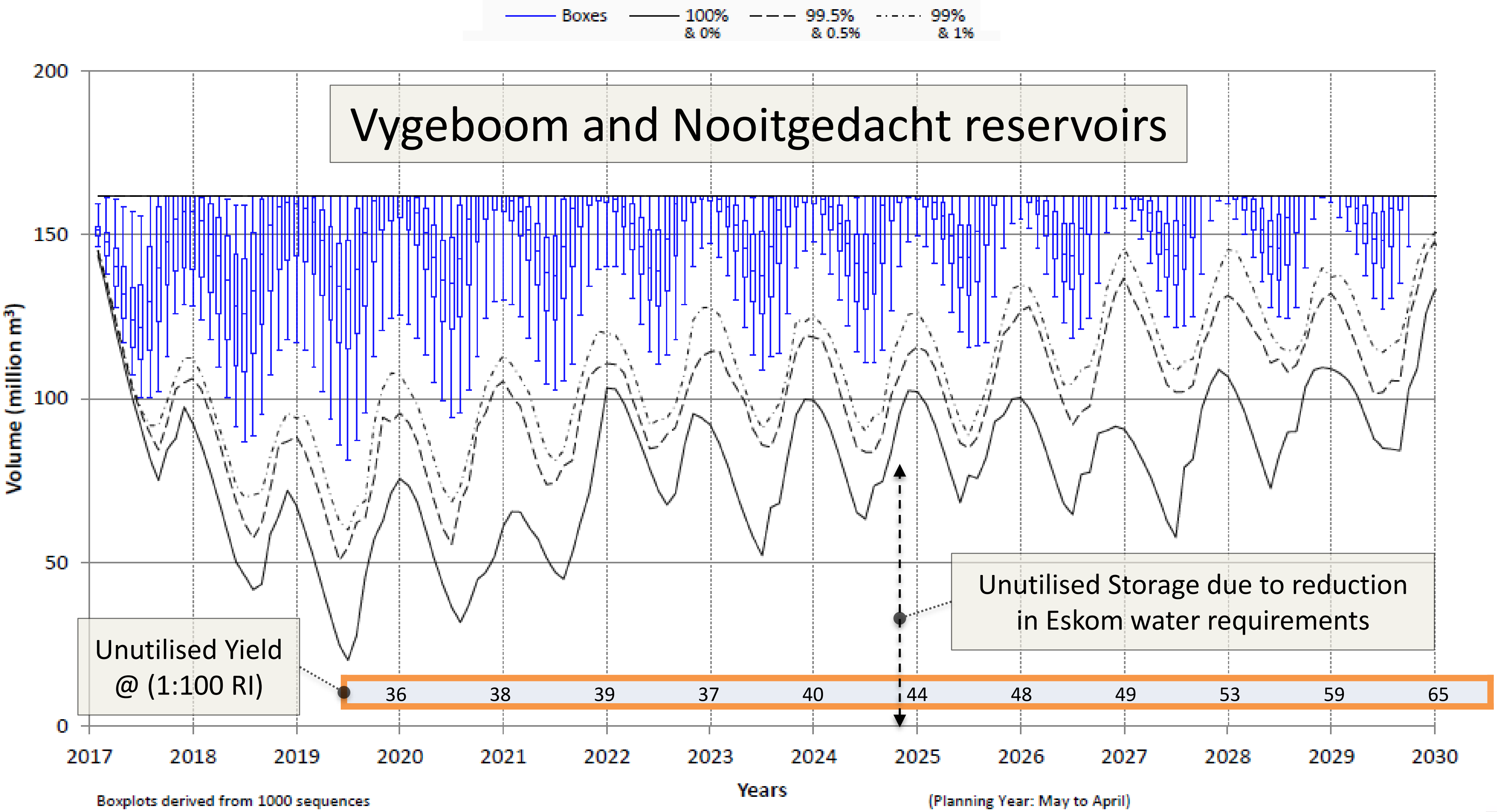
(April 2017 projection)



180 million m^3/a Reduction

Storage Projection of the Komati System

(Risk analysis AOA June 2017)



Vygeboom and Nooitgedacht reservoirs

Unutilised Yield @ (1:100 RI)

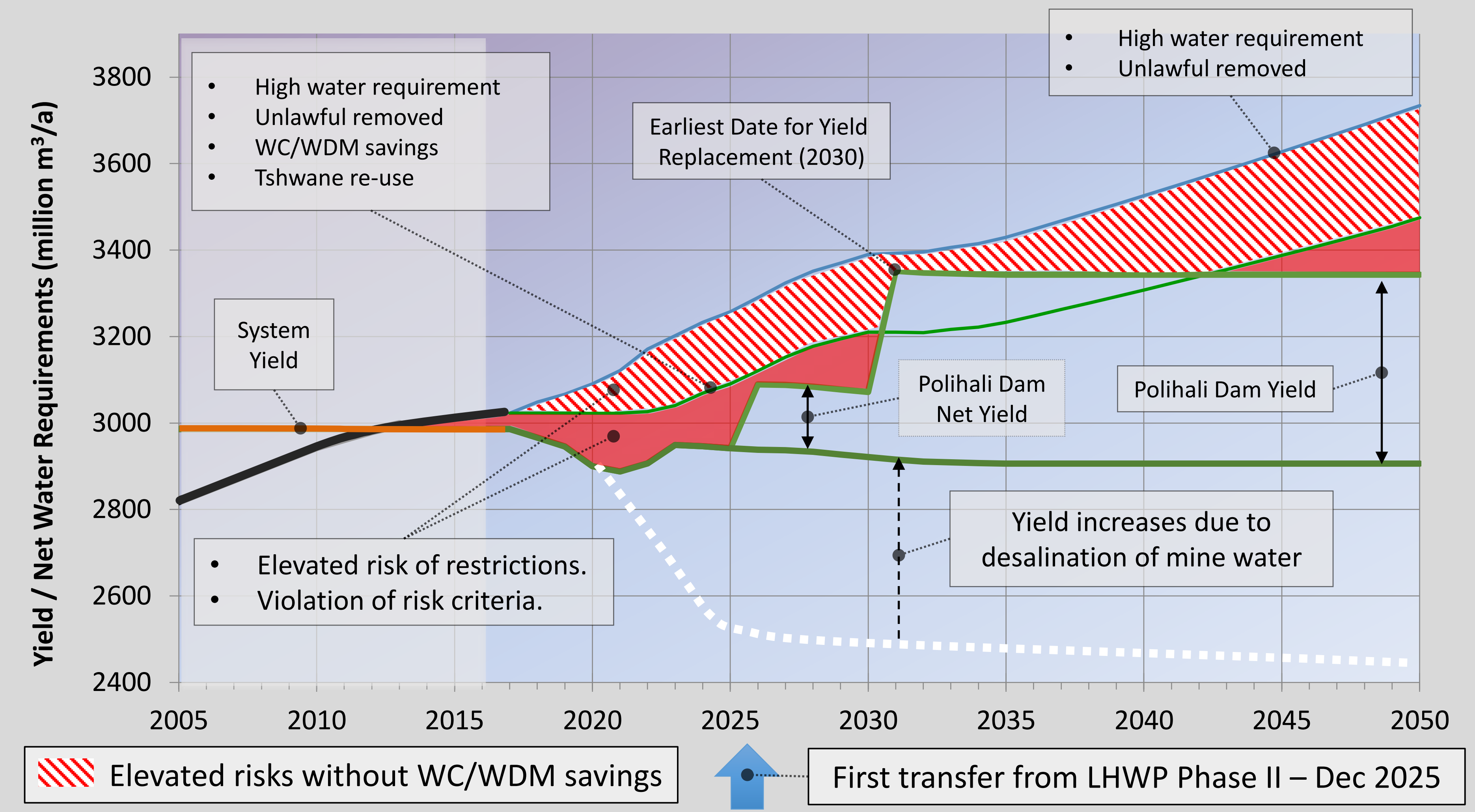
Unutilised Storage due to reduction in Eskom water requirements

Boxplots derived from 1000 sequences

(Planning Year: May to April)

Water Balance 2018

High with target WC/WDM	Desalination for urban use (from January 2022)	Unlawful removed	Re-use (Tshwane)



- High water requirement
- Unlawful removed
- WC/WDM savings
- Tshwane re-use

Earliest Date for Yield Replacement (2030)

- High water requirement
- Unlawful removed

System Yield

Polihali Dam Net Yield

Polihali Dam Yield

Yield increases due to desalination of mine water

- Elevated risk of restrictions.
- Violation of risk criteria.

▨ Elevated risks without WC/WDM savings

First transfer from LHWP Phase II – Dec 2025

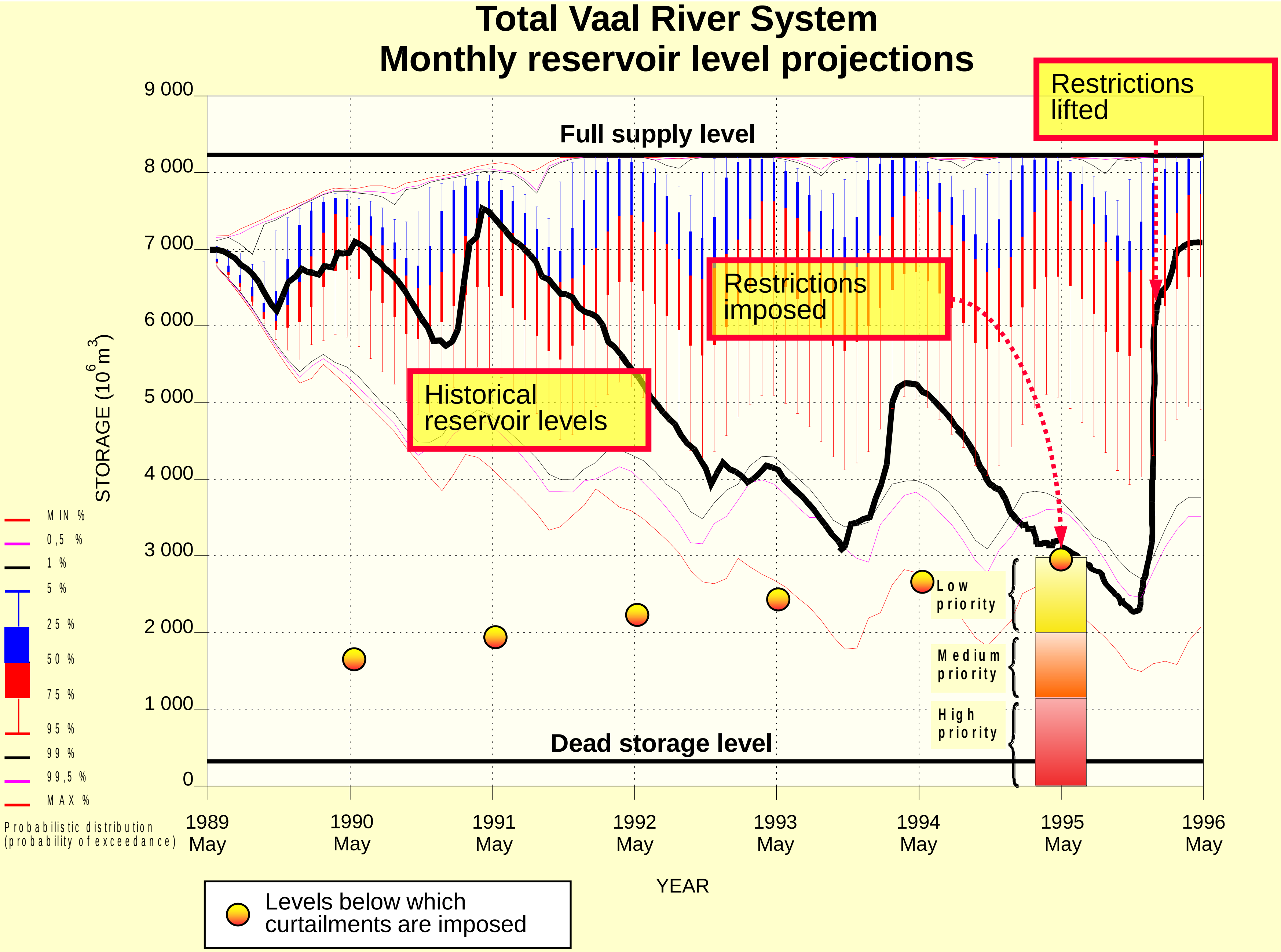
Conclusions

- Managing drought starts with long term risk based planning.
- Coherent scenario planning and consistent application of models focusses the debates on the consequences of the results rather than the results themselves.
- Planning methods and approaches need to be flexible to adapt to changing policies, evolving legislation, changes in the future water needs and the continuous advancing of the information technology environment.
- A key success factors that achieved high levels of integration and collaborations is due to DWS's operational method of cross attendance of PMC and Project Steering Committee meetings by officials from different DWS components & stakeholders.

Recommendations

- **Lecturers**: Ensure learners are exposed to these and other practical water resource planning, operation and management examples.
- **Learners**: Water resource management and planning is a divers field, require knowledge of law, models, institutional arrangement, hydrology, data management, economics, ecological health, public participation and engineering.
- **Practitioners**: Look out for opportunity to make water resource planning more efficient by embracing new technology where practical, improve accuracies and understanding, while staying on track with rigorous validation of facts.
- **Decision makers**: Embrace the knowledge documented in this paper and elsewhere. Resource allocation, human capacity building and dedication to develop and protect the water resources in an efficient manner must remain high on the agenda.
- A key success factor in water resource planning will be to **look out for disrupters** that will influence how and where water is used, distributed or conserved and by developing flexibility water resource provision strategies that can accommodate known and unknown change.

Drought Management Example



Total Vaal River System
Monthly reservoir level projections